RUI: Broken-Symmetry States of Confined Interacting Electrons

Charles Hanna, Boise State University, DMR-0206681

The PI and his students calculate experimentally measurable consequences of the combined effects of quantum confinement and interparticle forces in systems of electrons or bosons confined to two dimensions.

Electron systems -- Multilayer semiconductor devices with nanoscale layer separations and low electron densities are important technologically and scientifically. The technological interest stems from the need to understand the electronic properties of semiconductor devices with ultra small feature sizes and very low electron densities, a regime that is rapidly being approached in the semiconductor industry. The scientific importance of these devices is that they are ideal arenas to investigate the fundamental quantum many-body physics of confined, interacting electrons, including the possibility of broken-symmetry states.

Boson systems -- Bose-Einstein Condensates (BECs) were only recently (1995) realized experimentally although they were predicted by Einstein 71 years earlier. The PI, in collaboration with researchers at the University of Texas at Austin, studies rapidly-rotating, effectively 2D BECs. Possible applications of BECs include atomic lasers and quantum computers.

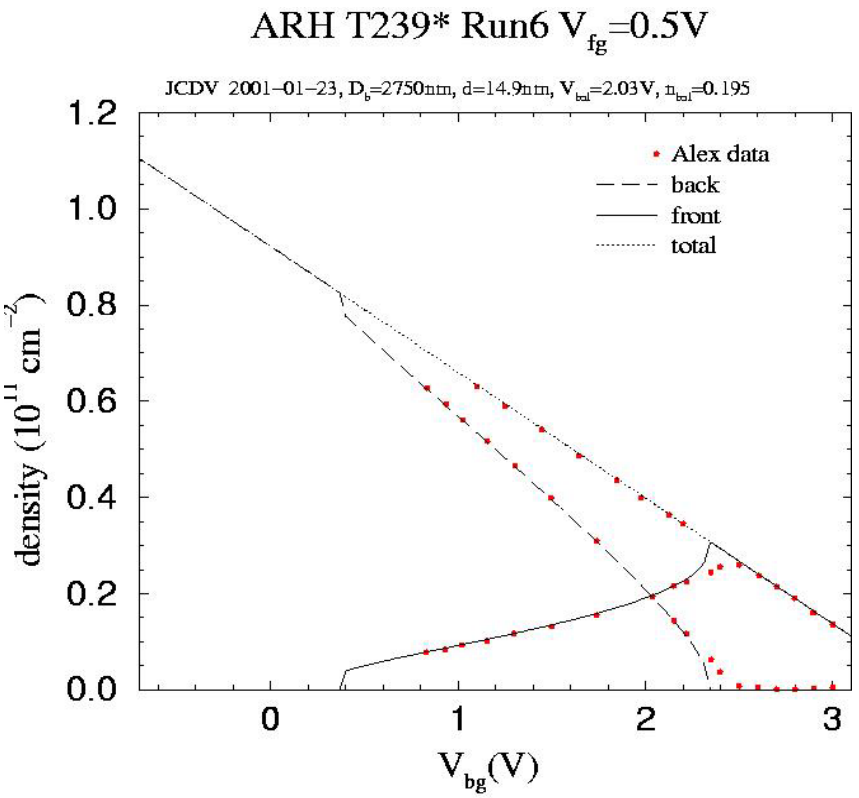

Figure 1. The PI's undergraduate students developed and used programs to fit experimental Shubnikov-de Haas data of layer densities versus voltage for low-density bilayer hole samples measured by Professor A.R. Hamilton. The model used is described in: C.B. Hanna, Dylan Haas, and J.C. Diaz-Velez, *Phys. Rev. B* **61**, 13882-13913 (2000).

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Educational:
The PI has carried out most of his research working with two student research assistants:

•Juan Carlos Diaz-Velez (graduate)
•James Rodriguez (undergraduate)

These students worked part-time during the academic year and full-time during the summer modelling confined, interacting electron and boson systems. They received training in computer programming, modern physics, physical modelling, mathematical analysis, and public speaking.

Collaborators:
The PI actively collaborated with faculty from two universities:
•A.R. Hamilton, University of New South Wales (experimental condensed-matter physics)
•A.H. MacDonald, University of Texas at Austin (theoretical condensed-matter physics)

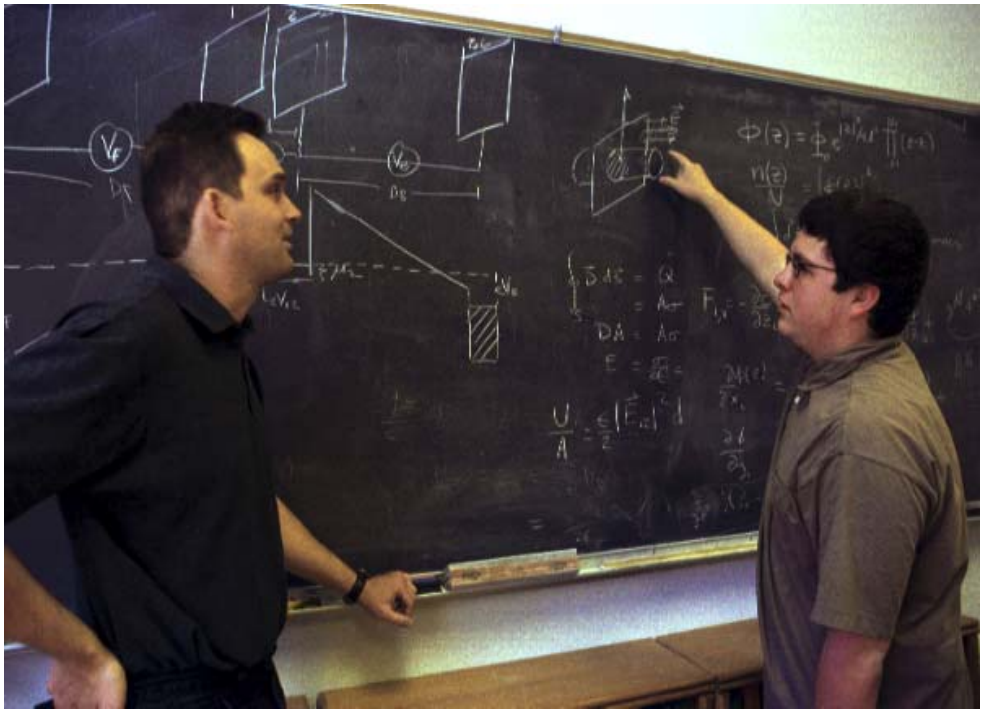

Figure 2. Juan Carlos Diaz-Velez (at left) and James Rodriguez discuss how to model double-layer electron systems. Both students have been supported by the NSF-DMR as research collaborators mentored by the PI.